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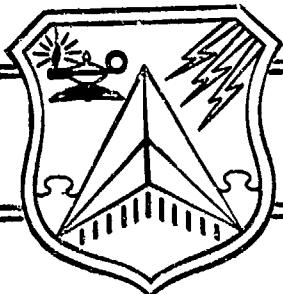
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By John N. Shults

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REPORT NO. 6060

CASE STUDY: LOCKHEED AND THE C-5A

by

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A RESEARCH REPORT SUBMITTED TO THE FACULTY

MAXWELL AIR FORCE BASE, ALABAMA

April 1976

ABSTAINER

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AIR WAR COLLEGE RESEARCH REPORT SUMMARY

NO. 6060

TITLE: Case Study: Lockheed and the C-5A

AUTHOR: John N. Shults, Lt. Colonel, USAF

A brief summary of the need for the C-5A aircraft by the United States and Lockheed Aircraft Corporation serves as an introduction to a discussion of the reasons behind the cost overrun involved in producing this massive aircraft. Government procurement practices are examined with emphasis placed on the Total Package Procurement Concept and the resulting C-5A contract. The causes of the cost overrun in the areas of contractual obligations, equipment problems, and management inefficiencies are presented along with a discussion of the alleged concealment of the mounting costs. Finally, the lessons learned from the C-5A experience are summarized.

About the Author

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CHAPTER I

INTRODUCTION

One of the military procurement programs which resulted in causing confusion and mistrust in the American public toward defense expenditures was the so-called "cost overrun" in the development and production of the C-5A aircraft by Lockheed Aircraft Corporation. Since the need for public confidence in defense procurement programs is of utmost importance when purchasing modern weapon systems, lessons learned from the C-5A procurement experience must be applied to future acquisition programs. The purpose of this case study is to provide a vehicle from which these lessons can be drawn. To accomplish this purpose, the study will examine those points which are pertinent in considering the Air Force's procurement of the C-5A, delineate the problems encountered by Lockheed in producing the aircraft, and summarize the lessons learned. Hopefully, review of this study will result in stimulating those personnel involved in acquiring future systems toward doing a better job, thereby regaining public confidence in military procurement practices.

The study is not a chronological documentary, but rather a compendium of those aspects of the C-5A procurement experience which appear to have had the greatest bearing on the increase in program costs. The material was drawn from a variety of sources, none of which could be considered entirely objective in its treatment of the circumstances surrounding the situation. The time period examined

begins in 1965 with the award of the C-5A contract to Lockheed using the Air Force's new Total Package Procurement Concept. It ends in 1968 when Mr. A. E. Fitzgerald, Deputy for Management Systems in the Air Force, acknowledged a \$2 billion overrun in the C-5A procurement program. Comments on C-5A equipment problems are as current as unclassified sources will permit.

CHAPTER II

BACKGROUND

To place the acquisition of the C-5A and related overruns in perspective, one must first look at the background of the problem and feel the magnitude and complexity of not only the dilemma in which Lockheed found itself but also the size and performance characteristics of the aircraft.

Description of the C-5A

It is difficult to describe the sheer size of the C-5A in words. Perhaps Berkeley Rice described it best in his book The C-5A Scandal when he said:

The C-5A is not merely huge--it is a public relations man's dream. Only 18 yards shorter than a football field, it has a 223-foot wing span and a tail six stories high. Its four, 16-foot, 7000-pound turbofan-jet engines are twice as powerful as any in existence and could furnish electricity for a city of 50,000 people. Its cavernous fuselage can swallow 14 jet fighters, 50 Cadillacs, or a 250,000-pound assortment of tanks, helicopters, cannons, trucks, or other equipment.

Despite its massive size, the C-5A handles easily, climbs quickly, and reaches speeds over 600 miles per hour. According to its specifications, it can carry twice the cargo of the next largest military cargo plane. It can theoretically fly nearly 3000 miles, land, unload, take off on a 4000-foot dirt runway, and return to its base without refueling. The C-5A is designed to operate at temperatures ranging from an Arctic 65 degrees below zero to the steaming

120 degree heat of Southeast Asia.² A built-in malfunction detector electronically monitors 600 test points, locates any troubles, and prints out repair instructions.

Special features permit the C-5A to operate into primitive landing strips that have no mechanical facilities for unloading. The plane's 28 tires can be deflated in-flight for landing on unpaved runways. It can lower itself three feet for loading and unloading, and wheeled cargo can simply drive up or down its built-in ramps. Because its nose swings up on hinges, the plane can be loaded or unloaded at both ends, cutting the normal load/unload time in half. In the event of resupply requirements not near a field, the rear of the aircraft can be opened in flight to permit airdrops of single loads up to 50,000 pounds. It is equipped with special avionics which enable it to pinpoint any target location at night or in adverse weather.³

US Need for the C-5A

What utility would the C-5A provide to the United States? Talk concerning the need for the giant jet transport began to be heard around the Pentagon by 1962, early in the reign of Defense Secretary Robert McNamara. With a fleet of such planes, the United States would be able to deploy fully equipped forces around the world on a day's notice. This could mean reducing the need for large contingents of U.S. troops stationed abroad, thereby cutting the balance of payments deficit as well as defense costs. Most important, this capability of immediate massive intervention would provide a more

flexible response to brush-fire wars and other strategic threats.

It will enable the United States to move major combat forces into action in hours rather than days or weeks.⁴

The military capability offered by an aircraft like the C-5A would significantly increase the strategic options available to the United States. Just 12 of them could have handled the entire Berlin Airlift, which required 224 planes in 1948. A fleet of 100 C-5As could transport 15,000 combat troops, including their equipment, from the U.S. to Europe in 24 hours. As one Defense Department official noted happily, "This will mean an Army Division in Kansas is just as much on the front lines as one in Germany."⁵

Lockheed's Need for the C-5A

In December 1964 the Air Force issued a Request for Proposal (RFP) for C-5A contract bids to three large aircraft manufacturing companies--Lockheed, Boeing, and Douglas (now McDonnell-Douglas). The competition between these companies for the contract award was intense. The reason for this intensity went beyond the desire to win a government contract. As Fortune magazine pointed out at the time, all three companies were ". . . aware that the stakes were appreciably greater than the program itself. The winners could expect to get a corner on the commercial market for a plane that promises eventually to become a standard workhorse of the air transport business."⁶ In effect, the winner of the C-5A contract would be financed by the Air Force while it developed the necessary technical and production experience for a potentially far more profitable

commercial airplane.

Lockheed, however, had other considerations in mind when deciding to bid on the contract. They were facing a bleak future. At the time of the C-5A bidding in 1965, Lockheed was nearing the end of its C-141 production run and, unlike Boeing and Douglas whose defense contracts were more or less balanced by commercial sales, Lockheed was almost completely dependent on the Defense Department. With no other major military or civilian contracts in sight, Lockheed simply had to win the C-5A contract or possibly be forced to lay off as many as 10,000 personnel.

Awarding the Contract

In April 1965 the three companies submitted their final bids for the 115 plane contract. Boeing was high with a bid of \$2.2 billion; Douglas was next at \$2 billion; and Lockheed was lowest with \$1.9 billion.⁷ After considerable study the Air Force C-5A Source Selection Board rejected the Douglas bid on the grounds of inadequate aircraft design. Lockheed's design met contract requirements after some last minute redesign of the wings and flaps; however, the board feared the design changes would cause schedule delays and cost increases. On the basis mainly of design superiority, the board finally picked Boeing's as the best proposal and sent its recommendation up to the top levels of the Air Force and Department of Defense for the final decision.⁸ However, the top Air Force officials overruled the experts on the Source Selection Board and awarded the C-5A contract to Lockheed. According to subsequent

testimony before Congress, General John P. McConnell, USAF Chief of Staff, cited Lockheed's low bid as the decisive factor, claiming it represented "a substantial savings to the Government."⁹

CHAPTER III

AIR FORCE CONTRACTING

Government Procurement Practices

The following discussion of government procurement practices is a summarization of description provided by Nash and Cibinic in their book Federal Procurement Law.¹

The U.S. Government obtains products and services through two different methods of procurement. The first and preferred method is formal advertising; the other is negotiated procurement. Each method is applicable under certain circumstances.

Formal advertising is the competitive system used by the government to select contractors when time and other conditions permit. Congress expressed its preference for this method early in our country's existence, and the highly technical and detailed rules which characterize it have gone through a long evolutionary period.

Formal advertising begins when a government activity, determining that it has need of a certain product or service, submits a purchase request, describing the product or service, to the contracting agency. This agency then issues an Invitation for Bids (IFB) which includes the complete specifications for the item and the timetable which will be followed in the procurement. The IFB is circulated as widely as possible in order to obtain maximum competition. At the specified hour, all bids which have been received are publicly opened and read aloud. From this time until the contract award is

made, no new bids may be submitted, none may be withdrawn, and no changes may be made.

The contracting agency then evaluates the bids which have been received. Each bid is checked for responsiveness, i.e., does it meet the specifications as stated in the IFB? The bids are then ranked according to price, and the lowest bidder is checked to determine if he is responsible. Responsibility concerns a bidder's capability to do the job as regards capacity, financial position, reliability, etc. If the lowest bidder is determined to be responsible, he is awarded the contract. If not, the next lowest bidder is checked for responsibility, and so on.

Certain criteria must be met to enable the use of formal advertising:

1. A complete specification or description must be available.
2. There must be at least two suppliers available for competition to be possible.
3. Award must be possible on the basis of price alone.
4. There must be sufficient time available to carry out the complete process from IFB to award, allowing the competitors sufficient time to prepare the necessary bids.

When the criteria for formal advertising cannot be met, the product or service required must be obtained through negotiated procurement. Quite often this is due to a lack of adequate specifications to describe the item desired, as when the desired end result is known, but not the method to obtain it. Under negotiated procurement, once the contracting agency is notified of what is required,

a Request for Proposals (RFP) is issued. The RFP is not as detailed a document as an IFB, because the specifications or other items may not be determined. At the set time, the proposals are opened, but not disclosed publicly. At this time the government contracting agency may either award on the basis of the proposals submitted, or may negotiate with the bidders. If negotiations are held with one bidder, they must be held with all. The award made as a result of negotiations need not be to the lowest bidder, but rather is made on the basis of the best advantage to the government, price, and other factors considered.

Types of Contracts

There are three general types of contracts for U.S. Government procurement: cost reimbursement, fixed price, and incentive. These are not truly separate types because some combining does occur, such as fixed price incentive or cost plus incentive.

In cost reimbursement contracts, the government reimburses the contractor for actual costs incurred. Various profit arrangements are possible, such as a predetermined fixed amount of profit (cost plus fixed fee), no profit (cost, no fee), or less than full payment of costs (cost sharing). These contracts are used primarily where the extent of the work cannot be accurately estimated at the time of contract signing.

In fixed price contracts, the contractor undertakes the work for a fixed amount of compensation. Under the firm fixed price, the fixed amount is determined when the contract is signed. In the

fixed price redeterminable, the fixed amount is determined during performance of the work. In the fixed price with escalation, the price is variable in accordance with predetermined procedures as the economic situation changes. Fixed price contracts are used when the work is well defined and costs can be accurately determined in advance.

In incentive contracts, the parties agree to a target cost, a target profit, and a profit formula which increases profits if actual costs are less than target costs and decreases profits if actual costs are higher than the target. Under the fixed price incentive contract a ceiling price is included and the contractor is obligated to complete the work at this price, but under the cost plus incentive fee contract the contractor is not obligated to continue if the government does not supply sufficient funds. Under the cost plus award fee contract the contractor earns a profit "bonus" or "penalty" which is subjectively determined by the government after an evaluation of the work. These contracts are used when it is agreed that pricing risks should be shared.

The C-5A Contract

The C-5A contract was a negotiated contract of the fixed price incentive type. The procurement could not be conducted through formal advertising because a complete specification was not available and the award could not be made on price alone. The contract was also the testbed for the Air Force's new Total Package Procurement Concept (TPPC). The objectives of TPPC can be summarized as

follows:

1. To secure the most complete price commitment possible for the complete effort (research and development, production and support) while still under the umbrella of competition.
2. To minimize sole-source negotiation in follow-on contracts.
3. To provide incentives for quality, on-time, low priced delivery.
4. To minimize buy-in. (Buy-in occurs when a contractor deliberately underbids the research and development phase of a major contract. He expects to make his profit later in the production phase when the government must negotiate on his terms because he is then the only contractor with the knowledge and ability to complete the job.)
5. To stimulate economy in planning, engineering and design from the outset.
6. To stimulate minimum cost make or buy decisions and competitive fixed price subcontracting.
7. To minimize production redesign.
8. To obtain 10-year cost effectiveness comparisons between competing systems as a basis for decision.³

The Request for Proposals (RFP) for the C-5A was issued in December 1964 to Lockheed, Boeing, and Douglas for the airframe, and to General Electric and Pratt and Whitney for the engines. The RFP consisted of 1500 pages and included a work statement and a model contract. The proposals were to be evaluated on the basis of an aircraft which met the minimum requirements in the RFP and provided the greatest cost effectiveness over a 10-year period based on both the initial buy of 57 aircraft and the optional buy of an additional 58 aircraft.

The competitors submitted their technical proposals and cost estimates in April 1965 and were required to sign definitive fixed price incentive contracts for development, production of 57 aircraft, and provisions for support. When the final selection was announced on September 30, 1965, awarding the contract to Lockheed-Georgia and General Electric, the accumulated paperwork weighed over 36 tons and nearly 500 people were required to cope with it.⁴ The Air Force estimated that the competing contractors and sub-contractors had spent over \$60 million during the competition.⁵

The government decided to contract separately with Lockheed and General Electric for their respective portions of the aircraft. However, overall responsibility was settled on Lockheed because it had agreed to the engine specifications.

The Air Force recognized that serious risks were being imposed upon the contractors in view of the duration of the contract and magnitude of the costs involved in the C-5A acquisition effort. Therefore, certain unique clauses were set forth in the contract to balance equitably the risks between the contractor and the government. The following discussion of the more important clauses was synthesized from the 1969 Air Force Review of the C-5A Program report.⁶

The first clause concerned cost and performance incentives. According to the contract, Lockheed's target cost for producing 115 C-5As was \$1.7686 billion. Adding on ten percent profit stipulated by the contract, the target price was calculated to be

\$1.9453 billion. A ceiling price to the government was established at \$2.2991 billion (130 per cent of target cost). Under the cost incentive clause Lockheed was required to pay 30 per cent of the costs over target up to the ceiling price. Additionally, the contractor would receive 50 per cent of any savings under the target cost. All costs over the ceiling price were to be borne by the contractor. Through this clause the government accepted some of the risk of Lockheed going over its target cost.

Performance incentives were established by combining range, payload and cruise speed parameters to reward the contractor for performance improvements which increased the potential productivity of the aircraft. Under this provision Lockheed would receive \$1.5 million for each percent of improvement in actual productivity over the target value up to \$22.5 million.

Failure to meet performance goals was not reflected in penalties, but was considered to be a deficiency. Under the correction of deficiencies clause, Lockheed was required to correct deficiencies without change to target cost until six months after operational testing was completed or, in the case of aircraft delivered after completing of testing, until six months after delivery.

Due to the length of the contract a clause was inserted to cushion the impact of possible abnormal fluctuations in labor or material costs. An inflation "normalcy zone" was created by the Air Force using projected annual earnings of production aircraft workers and the applicable wholesale price index prepared by the

Bureau of Labor Statistics. During the length of the contract any fluctuation in the economy which fell outside the zone would be considered abnormal and cause for target cost and ceiling price adjustment.

Since the contractor committed himself to binding technical performance requirements, delivery schedule and price of operational hardware prior to the start of detailed engineering design, there was a repricing clause included in the contract. The initial order was for 58 aircraft (5 RDT&E and 53 production models) with a firm pricing formula for follow-on production of 57 more. The repricing clause provided that, in the event that actual costs of the first 53 production aircraft exceeded the ceiling price by an amount up to 140.5 per cent of the target cost, the percentage difference between the ceiling price and 140.5 per cent would be multiplied by 1.5. The target cost of the 57 follow-on aircraft would be increased by the resulting percentage. If the actual costs exceeded 140.5 per cent of the target cost, the multiplying factor would be 2.0 rather than 1.5. Thus, if the contractor costs increase beyond the range of foreseeable risk, this clause could preclude a catastrophic loss to the contractor.

Finally, because late delivery would be extremely costly to the Air Force in terms of interfacing training and base facility construction, the contract contained a penalty clause for delayed aircraft delivery. Lockheed would be assessed \$12,000 per day per aircraft for late delivery of the 16 C-5As scheduled for the first

operational squadron. The maximum amount to be assessed would not exceed \$11 million.

To sum up the C-5A contract, it was a document which imposed total system performance responsibility on Lockheed. This responsibility was coupled with firm commitments on aircraft performance, delivery of all items making up the total system, price of the airframe including the avionics, and all non-government furnished equipment. The use of the fixed-price incentive type contract was designed to provide incentive to achieve a reasonably priced, producible aircraft. In explaining the reason for selecting this type of contract, Mr. Robert H. Charles, Assistant Secretary of the Air Force for Installations and Logistics, and father of the Total Package Procurement Concept, stated:

A fixed-price incentive contract is the most feasible type of award to be issued under the total package procurement plan. A straight fixed-price contract may apply to some areas where nothing more than routine engineering and production are involved, but where you're dealing with a system that hasn't been designed or developed when the contract is signed, the fixed-price incentive contract is best. Otherwise, you may be threatening corporate financial catastrophe, and that's the last thing we want.

CHAPTER IV

THE COST OVERRUN

On 13 November 1968 Mr. A. E. Fitzgerald, Deputy for Management Systems in the Air Force, acknowledged to Senator William Proxmire's Subcommittee on Economy in Government that the cost of the C-5A contract could be approximately \$2 billion more than originally estimated and agreed upon.¹ This admission caused a furor on Capitol Hill and placed further funding for C-5A procurement in jeopardy. The size of the cost growth or "overrun" was the major concern. Overruns on past government contracts have been many in number and high in percentage of initial estimates. However, a cost growth of \$2,000,000,000 is embarrassingly noticeable to everyone, especially to the taxpayer who is footing the bill and to Congress which must convince the taxpayer that his money was not wasted.

That an overrun did occur is an indisputable fact. What may be of benefit in future dealings is why. What caused it, what contributed to it, and what allowed it to reach such a magnitude? This chapter examines these questions by reviewing the causes and alleged concealment of the overrun. First, a brief summation of the cost data which verified the overrun is presented. Next, those factors which played a part in Lockheed's underestimation of the costs involved in producing the C-5A are discussed. Finally, an attempt is made to unravel the facts surrounding the alleged concealment

of the overrun.

C-5A Cost Summary

According to Senator Proxmire,² the following cost summary reflects the growth of the C-5A program in millions of dollars between April 1965 and October 1968:

	<u>April</u> <u>1965</u>	<u>October</u> <u>1968</u>
Research and Development (5 Aircraft)	977.0	1002.7
First Production Run (53 Aircraft)	1210.0	1551.1
Second Production Run (62 Aircraft)	891.0	1808.3
Spares Paid for by AFLC	293.0	968.0
 Total	3371.0	5330.1

This cost summary indicates that the total C-5A program, as envisioned in 1968, would cost almost \$2 billion more than was estimated in 1965. One should note that this estimate is based on procuring a total of 120 C-5A aircraft rather than the 115 reflected in the original contract. The extra five aircraft were included because the Air Force was recommending procurement of 120 aircraft in 1968.

In his examination of the C-5A cost growth Senator Proxmire indicated that the portion of the \$2 billion overrun attributed to Lockheed was \$1.16 billion.³ The rest was attributed to General Electric for the cost growth in its engine contract and to the Air Force for its 330 per cent cost growth in Air Force Logistics Command investment. Since this paper concerns Lockheed's part in the overrun, the reasons for the \$1.16 billion cost growth will be addressed.

Causes of the Overrun

In examining the causes of the overrun, a natural starting point would be to view the contract bid from Lockheed's position at the time the Request for Bids was released by the Air Force.

Lockheed had just completed production of the C-141 all-jet cargo aircraft for the Air Force. This left them, especially the Lockheed-Georgia division, in what may be viewed as a favorable yet precarious position. Having just built the C-141, they may have reasoned that the C-5A would be just another large cargo plane and could be built using the same facilities and technologies that were used in building the C-141. In review, this was probably their first major mistake. Another aspect to be considered by Lockheed was that with the C-141 project completed, the company needed a new large-scale contract for the Georgia division or be faced with the shutdown of the facilities there and the lay-off of a large number of personnel. They were opposed to this for two reasons. First, it was a step backward which meant reduction instead of expansion. Second, Lockheed was expecting a tight race for, but a favorable position in, the bidding for the upcoming contract for development of the United States Supersonic Transport aircraft which was soon to be offered.

For these reasons it was deemed necessary by Lockheed to keep its manpower intact and its facilities operating. The C-5A would do this, plus supply them with funds and manpower for research and development of large size, high speed jet aircraft, much of which

might be directly applied to the design and production of an SST aircraft. It could also gain them the title of "The World's Expert on Huge Aircraft," a much-coveted title.

That they felt it necessary to obtain the C-5A contract is also evidenced by the amount of money Lockheed spent to respond to the Request for Bids, an estimated \$16 million. Additionally, they submitted a very low (\$48 million) increase to the contract bid for technical changes requested by the Air Force. This was designed to make Lockheed's proposal more acceptable to the Air Force. The figure was estimated by the Air Force to be much too low and was later admitted by Lockheed to be the first major contributor to the cost overruns.⁴

Once the contract was awarded, it became necessary to at least make an attempt to meet the monetary terms--or was it? The Total Package Procurement Concept, and in particular its application in this case, may have had a reverse effect. It can only be a speculation as to whether the "Golden Handshake," as the contract's repricing formula was sometimes called, actually influenced Lockheed in their financial management of the contract. It must be acknowledged, however, that once the overrun began to occur in substantial amounts, it was in Lockheed's favor to allow the overrun to increase to a point slightly above 40 per cent of the contract price. This would allow them to take advantage of the repricing formula that would reimburse them approximately \$1.25 on the second production run for each dollar of overrun encountered on the first

run.⁵ According to Senator Proxmire, application of the repricing formula added \$320 million to the contract price.⁶

Another source of cost growth was Lockheed's failure to meet the Specific Operational Requirements (SORs) set forth in the contract. Soon after the contract was signed, Lockheed engineers, through wind tunnel tests, found their initial design produced too much drag to satisfy the short field capability listed as an SOR. To meet this requirement the nose had to be streamlined and the wing surface enlarged.⁷ This problem was apparently resolved without, in itself, contributing significantly to increased costs. However, it in turn created a problem which did contribute to increased costs--the C-5A was now above contractual weight limits. Lockheed first asked the Air Force to relax the weight ceiling and later, in early 1961, offered a weight for increased thrust trade-off. In both cases, their requests were denied.⁸

Forced to live with the contracted empty gross weight, Lockheed began in earnest to lighten the ship by introducing exotic, light-weight materials in place of more conventional steel and aluminum. To accomplish this substitution a massive redesign effort was instituted requiring untold engineering manhours. The effort required the hiring of additional personnel and payment of overtime during a period of high employment in the aerospace industry. At one time Lockheed had 850 British engineers employed. This major modification had to be done quickly to avoid falling behind schedule due to contractual penalties for late delivery.⁹

Examples of the materiel substitutions Lockheed developed were the use of titanium rivets and fasteners (the latter shortly led to more trouble), and chemical milling of skin surfaces.¹⁰

Beryllium was used for the brake linings in the main landing gear which saved 1800 pounds per aircraft.¹¹ As might be expected, the use of these led to sharp materiel price increases.

Once production started, another cause of rising prices occurred. Because the aerospace industry was at full capacity, special forgings needed from suppliers suddenly had delays of three or four times what had been envisioned in 1964. This either caused production delays or forced Lockheed to pay exorbitant prices to get preferential treatment.¹² Further, Lockheed experienced fabrication difficulties since they were breaking new ground in working with the exotic metals.¹³

No estimate has been established concerning the program cost growth due to Lockheed's attempt to bring the C-5A weight to within the contract specifications. It would seem reasonable to assume that the need to hire additional personnel, purchase exotic materials, and obtain preferential treatment from suppliers, resulted in a significant portion of the 1969 cost growth estimate. (Additional equipment problems surfaced after Senator Proxmire's cost overrun estimate was published. These problems are addressed in Chapter V.)

Creation by Lockheed of a new management team and new management concepts may have contributed to the cost overrun. The management organization was staffed 15 levels deep and required special

communications information and control in order to assimilate the activities of the more than 55 major subcontractors required to fulfill the contract. An integral part of this management system was the implementation of a data processing system called "Sentinel." A particular facet of this system which could have been a causative factor in the overall cost was the "Program Evaluation and Review Technique of Technical Factors" (PERT/TECH). This program was designed to aid the project by forecasting the technical needs as derived from inputs supplied by all of the engineering departments. The approach was to identify the specific performance characteristics for the aircraft, then the engineers would list all of the design features necessary for production.¹⁴ Since one item may be considered more important or necessary in completing the end product than another, the design features were weighted numerically when entered in the program. While the idea is basically sound, given the time to eliminate inequities in weighting and other factors, a data processing program of this size might itself take several months to build and refine. Since it was a new concept, there were no previous guidelines on which to base the weighting factors or the soundness of all engineering features inserted. This could easily have led Lockheed management into making incorrect or at least inaccurate decisions.

An additional contributory factor may have been the new management concept which had all areas reporting their problems and potential problem areas upward to the directorate level. The concept

was termed "Management by Exception" since it was geared to respond primarily to correcting problems. This type of management has become increasingly popular and has considerable merit. However, it does have at least one weakness--top management must know their line managers well enough to trust them and their ability to solve most problems encountered. In turn, line management must have confidence in upper management--that problems reported to them will not be viewed as incompetency on the line manager's part. The rapid build-up of personnel may not have allowed time to build this confidence. Therefore, delays may have resulted because a supervisor might hesitate in reporting his problems to higher management. What delays might have been avoided by timely reporting or would not have occurred if an older, more established management method had been used can only be conjecture. It appears, however, that the use of a new management concept at this time may not have been a prudent move.

The following is a summary of the causes and contributors to the overrun:

First, the almost sole reliance of Lockheed upon government contracts at the time of the bidding. This led them to enter a low bid, anticipating that they could still make a profit through design changes and later "follow-on" activities.

Second, the repricing formula for the second run may have had a reverse incentive effect once Lockheed reached significant cost overruns.

Third, the need by Lockheed to hire additional personnel, purchase exotic materials, and obtain

preferential treatment from suppliers.

Fourth, the creation of a new management concept and new data processing system for production control.

Concealment of the Overrun

An important part of any discussion of the C-5A overrun is whether the Air Force concealed unfavorable information from the Congress and the general public. Much has been written on this subject and the evidence is open to interpretation. This section addresses the major arguments presented both for and against the allegation that the Air Force attempted to conceal the overrun.

Those that attempt to prove that the Air Force did conceal the overrun present the following facts. In early 1967 the C-5A Systems Program Office reported contract deficiencies and attempts by Lockheed to maneuver within the contract. These reports were marked for use only in the event of press inquiry, and when press questions failed to develop, the reports were not released.¹⁵ In February 1967, the Air Force issued a "cure notice" to Lockheed stating that unless current technical deficiencies were soon solved, the contract might be terminated for default. Lockheed convinced the Air Force to rescind the notice but were informed that the cost of the contract was going to be investigated. The investigation findings were never released.¹⁶ After rumblings by Congress about cancelling the C-5A, the Air Force directed that cost information be limited to top level reports and be excluded from any document receiving wide circulation.¹⁷ Finally, when the Air Force projected

a \$2 billion overrun in October 1968, it failed to promptly inform the Congress.¹⁸

According to the Air Force, the alleged concealment did not take place. In its 1969 Air Force Review of the C-5A

Program report,¹⁹ the Air Force rebutted any criticism of its actions by stating, "The Systems Program Office reporting to higher headquarters has been accomplished in an extensive, detailed, periodic, and timely manner. . . . All cost and technical data known at the time of (Congressional) testimony was disclosed."

The Air Force also points out that there is no procedural or policy requirement to disclose cost estimates between scheduled testimonies.²⁰

The argument between governmental departments, the Congress, and the public, over what needs to be reported, and when, continues to be debated. In the case of the C-5A, all parties appear to have reasonable criticisms and retorts. Perhaps the most definite conclusion that one can draw is that perceptions of what is taking place are different depending on where one stands.

CHAPTER V

EQUIPMENT PROBLEMS

This chapter is devoted to equipment problems which were discovered during productional testing. While these problems came to light after the case study time period, their influence on subsequent consideration of the success or failure of the C-5A procurement program is sufficient to require a short review. Discussion of the problems is divided into two parts. First, those problems which have been corrected or being worked on will be addressed. Second, the deficiencies for which no serious action has yet been taken will be discussed. Costs of solutions, where available, are reflected.

Deficiencies Which Have Received Attention

In dealing with this subject it seems appropriate to begin with the wing problem. This is the deficiency which has received the most publicity and has proven both expensive and elusive to correct. In fact, as will be shown in the final section, the problem is still not totally resolved.

Static stress tests on the wings of unflown C-5As conducted by Lockheed produced small cracks with the wing spars. The cracks occurred in the summer of 1968 under stresses of 128 per cent and 83 per cent of normal operating limits. This was against contract specified strength of 150 per cent.¹

Yet another wing crack, 8 to 10 inches in length, was found on

"Ship" 3 in January 1969. This airplane was Lockheed's structural test bird which had been flown making maneuvers above and beyond normal operating limits. At this point, all C-5As being flown were grounded for 48 hours for careful inspection; no additional cracks were found.²

To solve this deficiency, Lockheed designed new wing spar fasteners to be installed at eleven points on each wing. Basically, the modification was one of material. The original fasteners were of titanium which were removed in favor of ones made of steel, aluminum and titanium. Added weight was 250 pounds per aircraft.³ The original cost estimate (January 1970) was \$80,000 per aircraft.⁴ Within six months, the figure had risen to \$185,000 per aircraft.⁵ This fix only partially solved the problem. In terms of cargo capability, the C-5A could now safely carry 170,000 pounds or 80 per cent of the originally planned payload.

The second wing modification is called the Lift Distribution Control System. This system senses stress on the wing and adjusts the aileron to reduce the stress. The system, once installed, promised to raise the capacity to 190,000 pounds.⁶ By early 1973 the Air Force was estimating a total cost for this modification of \$211 million.⁷

A second structural deficiency appeared in the engine mounts or pylons. As Representative Moorhead noted in December 1969:

Failures have been experienced with the engine mounts. Therefore, restrictions have been imposed on

engine throttle limits and the plane cannot take off from unimproved runways.

Lest anyone should be able to accuse Moorhead of exaggeration, an engine obligingly fell off a C-5A during takeoff at Altus AFB, Oklahoma, on September 29, 1971.⁹ By June 1972, a permanent fix for the pylon had been developed with fleet-wide modification completed within a year and a half.¹⁰

Another technical problem that faced Lockheed was meeting the SOR life expectancy for the C-5A. This deficiency is essentially a function of the structural weaknesses found in the wing and so, as money has been spent on the wing, the longevity of the plane has increased. For example, in April 1972, Secretary of the Air Force Robert Seamans told Congress that at present the C-5A life expectancy is only 7,000 flying hours versus a contract specification of 30,000 flying hours.¹¹ However, the above discussed wing modifications have raised the figure to 20,000 hours.¹²

The landing gear created a significant amount of unwanted technical problems for Lockheed. Some of the difficulties also created unneeded publicity. For example, in February 1970, "Ship" 10 blew eleven of the twenty-four main gear tires upon landing at Robins Air Force Base, Georgia, because of a known valve deficiency which could, and in this instance did, lock the wheels.¹³ In May 1970, a C-5A making an emergency landing at Altus Air Force Base, Oklahoma (the plane had lost pressurization), had the main gear partially collapse.¹⁴ Finally, in the presence of the late L. Mendel

Rivers, a C-5A landing at Charleston Air Force Base, South Carolina, on June 6, 1970, had a wheel leave the airplane due to a washer failure.¹⁵ However, these incidents were to prove to be minor symptoms.

The C-5A landing gear is designed to "knee" to allow rapid load/unload, and the contract specified a maximum of two minutes to raise or lower the air frame. Lockheed originally built a pneumatic system that was found to take as long as twelve minutes.¹⁶ By early 1973 a hydraulic system had been substituted which lowered the time to six minutes.¹⁷

The C-5A landing gear, admittedly complex, produced an unacceptable failure rate. Statistics for March through August 1971 averaged one malfunction for every four hours of flight. To ease this problem the electrical system was scrapped in favor of a solid-state system.¹⁸ The source indicates the gear is not any more reliable; it is just easier to fix.

The TF-39 jet engines built by General Electric also had technical problems. During the first two years of flight the C-5A was ordered not to fly at certain power settings; they produced abnormal stress on the engine blades, causing them to crack.¹⁹

By 1972 the TF-39 engines had passed its between-overhaul-time milestones, but continued to show fatigue problems in certain vanes and the housing case. By late 1973 the responsibility for the engine had been turned over to the Air Force Logistics Command which meant that no further development problems were surfaced.

Undercapabilities

This section on equipment problems can best be titled Undercapabilities. These are failures to meet contract specifications but it appears that no serious attempt has been made to correct them.

One of the features of the C-5A was to be the ability to use unimproved runways with a minimum length of 4,000 feet. A. E. Fitzgerald in his book, The High Priests of Waste, gave the following quote extracted from a 1971 General Accounting Office study on the C-5A:

Although the landing gear was designed to permit landings and takeoffs from forward area runways (matted or bare soil), the aircraft have been restricted to hard surface runways. Flight tests on unimproved runways caused severe damage to jet engines, matted runways and aircraft. The tests were discontinued.²⁰

In March 1973, another GAO report was published stating that a "limited capability" for using "support area fields" was now under testing and that the Air Force had developed an engineering change to meet the original specifications. However, no decision had been made to implement the change.²¹ No further comments on this deficiency could be found in the literature.

The same void was encountered concerning Representative Moorhead's charge in December 1969 that the cargo door could not be opened in flight, and hence the C-5A could not perform its contractual paradrop mission.²²

The terrain-following radar with a minimum altitude SOR of 300 feet above the ground has never worked satisfactorily. Initially

it was totally unreliable, but early debugging made it work at 1500 feet.²³ By early 1972 the GAO reported the minimum down to 1000 feet and a cost estimate of \$13 million to reach the SOR limit.²⁴ One year later the Military Airlift Command decided the C-5A would not be flying below 1000 feet anyway, so no fix was implemented.²⁵

The SORs for payload of 220,000 pounds and life expectancy of 30,000 flying hours have not been met nor have cost estimates for doing so been announced. The limits of each now stand at 190,000 pounds and 20,000 hours.²⁶ Both deficiencies are due to the wing structure, caused either by the inherent design or by the changes made to lighten the aircraft.

CHAPTER VI

CONCLUSION

This chapter addresses key events in the C-5A procurement program since 1969, the lessons which the Air Force learned from the C-5A procurement experience, and actions taken by the Air Force in subsequent procurement programs as a result of the lessons learned.

Key Events Since 1969

On 14 November 1969 the Department of Defense formally announced its decision to limit the total C-5A procurement to 81 aircraft vice the 120 envisioned in 1968.¹ The Air Force cited budgetary pressures as the reason for the decision, explaining that an additional \$149 million would be required to complete the original program.²

On 17 December 1969 the Air Force took delivery of the first C-5A. General James Ferguson, Commander of the Air Force Systems Command, praised the aircraft, calling it "an exceedingly versatile instrument of national policy and a genuine revolution in aeronautics."³ Representative William S. Moorhead of Pennsylvania felt quite differently. He stated that "there are 25 acknowledged deficiencies in these planes" and recommended that the Air Force not accept any aircraft until the deficiencies are corrected.⁴ His advice was not taken and in May 1973, when the last aircraft was delivered, many of these deficiencies were still present.

On 1 February 1971, Lockheed agreed to absorb a \$200 million

loss on the C-5A development-production program in lieu of pressing litigation proceedings against the Department of Defense to recoup a substantial portion of its projected losses under the present

⁵ contract. Lockheed's acceptance was based on Deputy Secretary of Defense David Packard's decision that further funds would not be released for continued C-5A production while litigation was in pro-

⁶ cess. Once Lockheed agreed to accept the loss, work began to re-structure the contract. This effort culminated on 31 May 1971 when a cost-minus-fixed loss agreement replaced the original contract between the Air Force and Lockheed. With this action came the demise of the Total Package Procurement Concept and its fixed-price-incentive type of contract for C-5A procurement.

Lessons Learned

Did the Air Force learn anything from the C-5A procurement experience? The answer can best be stated by considering the recommendations of a special C-5A Review Council formed in 1969 at the request of then Secretary of Defense Melvin Laird. On the basis of its painstaking analysis of the C-5A program, the Review Council formally presented a ten point set of recommendations which are broadly applicable to other programs. They are summarized as follows:

1. Subject to greater flexibility and tailored to e. h. case, the Total Package Procurement Concept should be retained and refined on a selective basis.
2. Contracts which combine production with Research and Development (R&D) must be structured to adopt repricing, total system responsibility, and

corrections of deficiencies to each individual procurement so that the appropriate degree of responsibility will be vested in the contractor. Repricing formulas must not be permitted to lead to reverse incentives.

3. The handling of the economic fluctuation (inflation) clause requires definite standards, applied and understood uniformly by all bidders.
4. Uncertainties inherent in cost estimates require that such estimates be expressed early in the life of the program in ranges which are periodically updated.
5. Cost visibility must be maintained throughout the contract, even when the extent of the economic risk assumed by the contractor dictates that cost management should be left primarily to him.
6. The longer the performance life cycle of contracts involving R&D and production, the more careful the review to determine that the contract definition phase has been really complete and effective.
7. Before committing the government to a production contract, contractual development milestones should be established and critically reviewed. These development and production milestones should be the primary tools used by the government in maintaining visibility of the program.
8. Congress is to be informed rapidly and fully concerning program status and cost estimates of major weapon systems.
9. Major System Program Offices must be organized early in the systems life cycle and staffed with highly qualified and trained personnel, with staff turnover held to a minimum.
10. The government should develop independent cost estimates prior to source selection to judge the effectiveness of the program and for use in evaluating contractors' proposals.⁷

It appears that these recommendations fall under three headings:

program flexibility, total visibility, and effective control. Since the C-5A procurement program set forth stringent aircraft specifications which could not be changed, there was no flexibility to make cost-effectiveness tradeoffs subsequent to signing the initial contract. A less expensive aircraft might have evolved if tradeoffs had been allowed. Visibility by the Air Force of C-5A program activities appeared to be lacking throughout the procurement effort. This may have been due to the "hands off" policy called for by the Total Package Procurement Concept. This policy of non-interference assumed that the contractor would make the best possible decisions for the Air Force.⁸ With better visibility the weaknesses in the program would have shown up earlier. The non-interference policy also resulted in the Air Force having no control over the procurement program. The program was "set in concrete" from the beginning. With control in the hands of the Air Force rather than the contractor, cost discipline could have been made a priority effort. All in all, if the Air Force had been given the flexibility, visibility, and control which was not available under the Total Package Procurement Concept, the C-5A procurement program would have been much more successful.

Application of Lessons Learned

If the lessons learned reflected above have resulted in improved development and procurement activities, the ordeal of the Air Force's role in the C-5A overrun may have been compensated for, at least in part. A brief examination of two programs initiated

after the 1969 C-5A program review provides some insight into the seriousness with which the Air Force is applying the lessons learned. The F-15 and B-1 procurement programs appear to be excellent examples in that they both are large, expensive projects which required pushing the technological state-of-the-art. At first glance one might be inclined to believe that, since the costs of these programs have risen since their inception, the Air Force is ignoring the lessons learned from the C-5A experience. It must be realized, however, that a large portion of this cost growth has been caused by inflation which is beyond the control of the Air Force. Therefore, a deeper inspection is required before a judgement is made.

In considering the F-15 procurement program, it should be noted that the cost-plus-incentive contract is the same type as that used for C-5A procurement. However, there is flexibility built into the development phase of the contract. This flexibility allowed the Air Force to decide on performance and cost tradeoffs which resulted in simplified structural design.⁹ The contract also provides control points in the form of contract milestones. These milestones had to be adequately met or the program could have been realigned or terminated. The F-15 development phase of the program required extensive hardware testing before a production decision was made. This increased Air Force visibility in the area of equipment problems and permitted correction before full scale production began. Therefore, expensive modifications downstream were avoided.

The B-1 procurement program was set up to give the Air Force even more management flexibility than it had on the F-15. The development phase of the B-1 program is completely separate from the production phase.¹⁰ The B-1 design features were not frozen at the beginning of the program since the Air Force could not be sure how much the development of various capabilities would actually cost. A cost-reimbursement contract was used in the development program, thus permitting the Air Force to keep complete control over various tradeoffs that might be possible.¹¹ Like the F-15, the B-1 is undergoing extensive flight testing to insure successful design of major components before a production decision is made.

From this brief discussion of two major weapon systems which were started after the C-5A review, it appears that the Air Force is seriously attempting to implement the lessons learned from the C-5A procurement experience. Continued emphasis in this direction should result in more defense capability for the amount of funds expended and insure that an overrun, like that of the C-5A, does not occur again.

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Maxwell AFB, AL 36112-6424

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Washington, DC 20330-1000

Dear Ms. McLean,

Enclosed is the previously restricted LIMDIS document from AWC, "Lockheed and the C-5A." AU/PA has cleared the document for public release.

Please let me know if I can assist further,

Sincerely,

ANNE M. O'CONNOR, Archivist
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Atch:

- (1) Case Study: Lockheed and the C-5A, April 1976
- (2) Correspondence between AFHRA and AU/PA clearing the LIMDIS Restriction

07-M-2827



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2 Atch
1. AFHRA/RSA Memo, 20 May 08
2. Document for Review (U)

07-M-2827



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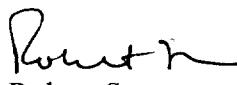
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2. USAF response
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